whales, sei whales, humpback whales, sperm whales, the blackfish group, and delphinids. Minke whale pulse-trains occurred almost continuously during the winter deployment but were absent in fall. Right whale events occurred mostly during winter at shallow-water sites, but unexpectedly were also detected at deep-water sites. Sperm whale events occurred exclusively near the continental shelf break and exhibited a strong diel pattern. Minke whale events had a strong negative relationship with sonar events. These results provide an initial assessment of marine mammal occurrence within the Navy's planned USWTR, and provide new information on vocalization events in relation to sonar.

**4:30**

**2pABb5. Vocalization behaviors of minke whales in relation to sonar in the planned Undersea Warfare Training Range off Jacksonville, Florida.** Talia Dominello, Thomas Norris, Tina Yack, Elizabeth Ferguson, Cory Hom-Weaver (Bio-Waves Inc., 364 2nd St. #3, Encinitas, CA 92024, talia.dominello@bio-waves.net), Anurag Kumar (Naval Facilities Eng. Command Atlantic, Norfolk, VA), Jene Nissen (U.S. Fleet Forces Command, Norfolk, VA), and Joel Bell (Naval Facilities Eng. Command Atlantic, Norfolk, VA)

Nine Marine Autonomous Recording Units (MARU's) were deployed in a rectangular array at a site coinciding with the United States (U.S.) Navy's planned Undersea Warfare Training Range (USWTR) approximately 60–150 km offshore Jacksonville, FL (13 September to 8 October and 3 December to 8 January, 2009–2010) at shallow, mid-depth, and deep sites (45, 183, 305 m). Data were reviewed in detail using TRITON (Wiggins, 2007). Event logs were created for each day at every site. Custom-written MATLAB scripts were used to calculate the probability of minke whale vocalization events occurring in the presence and in the absence of mid-frequency sonar. Minke whale vocalization events were completely absent in the fall deployment period, but occurred almost continuously during the winter deployment, indicating a strong seasonal pattern of occurrence. Minke whale vocalizations were detected most frequently at deep-water sites, and only at low levels (<0.03% of time) at shallow-water sites. Results of the probability analysis indicated a strong negative correlation to sonar. Minke whale vocalization events were greatly reduced, or completely ceased, during most days with nearly continuous sonar events during an approximate 3-day period. To our knowledge, such changes in acoustic behaviors of minke whales in relation to sonar have not been reported before.

**4:45**

**2pABb6. Behavioral responses of California sea lions (*Zalophus californianus*) to controlled exposures of mid-frequency sonar signals.** Dorian S. Houser (Dept. of Conservation and Biological Res., National Marine Mammal Foundation, 2240 Shelter Island Dr., San Diego, CA 92106, dorian.houser@nmmfoundation.org), Stephen W. Martin, and James J. Finneran (US Navy Marine Mammal Program, SSC Pacific, San Diego, CA)

Acoustic dose-response functions can be used to explore the relationship between anthropogenic noise exposure and changes in marine mammal behavior. Fifteen sea lions participated in a controlled exposure study to determine the relationship between the received sound pressure level (SPL) of a mid-frequency sonar signal (1-s duration, 3250-3450 Hz) and behavioral deviations from a trained behavior. Sea lions performed 10 control trials followed by 10 exposure trials within an open-water enclosure. Acoustic playbacks occurred once during each exposure trial when the sea lion crossed the middle of the enclosure. Received levels, ranging from 125 to 185 dB re 1 $\mu$Pa (rms) SPL, were randomly assigned but were consistent across all trials for each individual. Blind scoring of behavioral responses was performed for all trials. A canonical correlation analysis indicated that cessation of the trained behavior, haul-out, a change in respiration rate, and prolonged submergence were reliable response indicators. Sea lions showed both an increased responsiveness and severity of response with increasing received SPL. No habituation to repeated exposures was observed, but age was a significant factor affecting the dose-response relationship. Response patterns and factors affecting behavioral responses were different from those observed in bottlenose dolphins and are indicative of species-specific sensitivities.

**5:00**

**2pABb7. The characteristics of boat noise in marine mammal habitats.** Christine Erbe (Ctr. for Marine Sci. & Technol., Curtin Univ., Kent St., Bentley, WA 6102, Australia, c.erbe@curtin.edu.au)

Environmental management of underwater noise tends to focus on sources related to offshore oil and gas exploration and navy operations. However, in many, specifically near-shore habitats, boat noise prevails, yet remains largely unregulated. Underwater noise of personal watercraft (jet skis) was recorded in Queensland, and consisted of broadband energy between 100 Hz and 10 kHz attributed to the vibrating bubble cloud generated by the jet stream, overlain with frequency-modulated tonals corresponding to impeller blade rates and harmonics. Broadband monopole source levels were 149, 137, and 122dB re 1 $\mu$Pa @ 1m (5th, 50th, and 95th percentiles). Underwater noise of zodiacs (inflatable boats with outboard motors) operated by whale-watching companies was recorded in southern British Columbia. At slow cruising speeds (10 km/h), underwater noise peaked between 50 and 300 Hz; at fast traveling speeds (55 km/h), underwater noise peaked between 100 and 3000 Hz, exhibiting strong propeller blade rate tonals at all speeds. Broadband source levels increased with speed from 126 to 170dB re 1 $\mu$Pa @ 1m according to SL = 107 + 32 log10(speed/km/h). Even though noise levels from jetskis are lower than those of propeller-driven boats, it is not necessarily the broadband source level that correlates with the bioacoustic impact on marine fauna.

**5:15**

**2pABb8. Complex masking scenarios in Arctic environments.** Jillian Sills (Ocean Sci., Univ. of California at Santa Cruz, 100 Shaffer Rd., Santa Cruz, CA 95050, jmsills@ucsc.edu), Colleen Reichmuth (Inst. of Marine Sci., Univ. of California at Santa Cruz, Santa Cruz, CA), and Brandon L. Southall (Southall Environmental Associates, Aptos, CA)

Critical ratios obtained using octave-band noise and narrowband signals provide a useful first approximation for understanding the effects of noise on hearing. When considering realistic listening scenarios, it may be necessary to examine the effects of spectrally complex, time-varying noise sources on an animal's ability to detect relevant signals. In the case of Arctic seals, the increasing prevalence of seismic exploration makes an examination of masking by impulsive sounds particularly relevant. However, the characteristics of received sounds from airgun operations vary dramatically depending on the seismic source, environmental parameters, and distance. In order to determine the potential for auditory masking by airguns, we developed a paradigm to quantify the influence of spectral and temporal variations in typical seismic noise on signal detectability. This method calls for calculation of detection probabilities for seals listening for the same signal embedded at different time windows within a background of distant airgun noise. We believe this approach will enable an experimental assessment of masking potential by impulsive noise as distance between the receiver and source is increased. Such an assessment will aid in determining the extent to which standard critical ratio data can be reasonably applied in complex masking scenarios. [Work supported by OGP-JIP.]